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Colorado State Univ, Fort Collins Dept of Industrial Sciences

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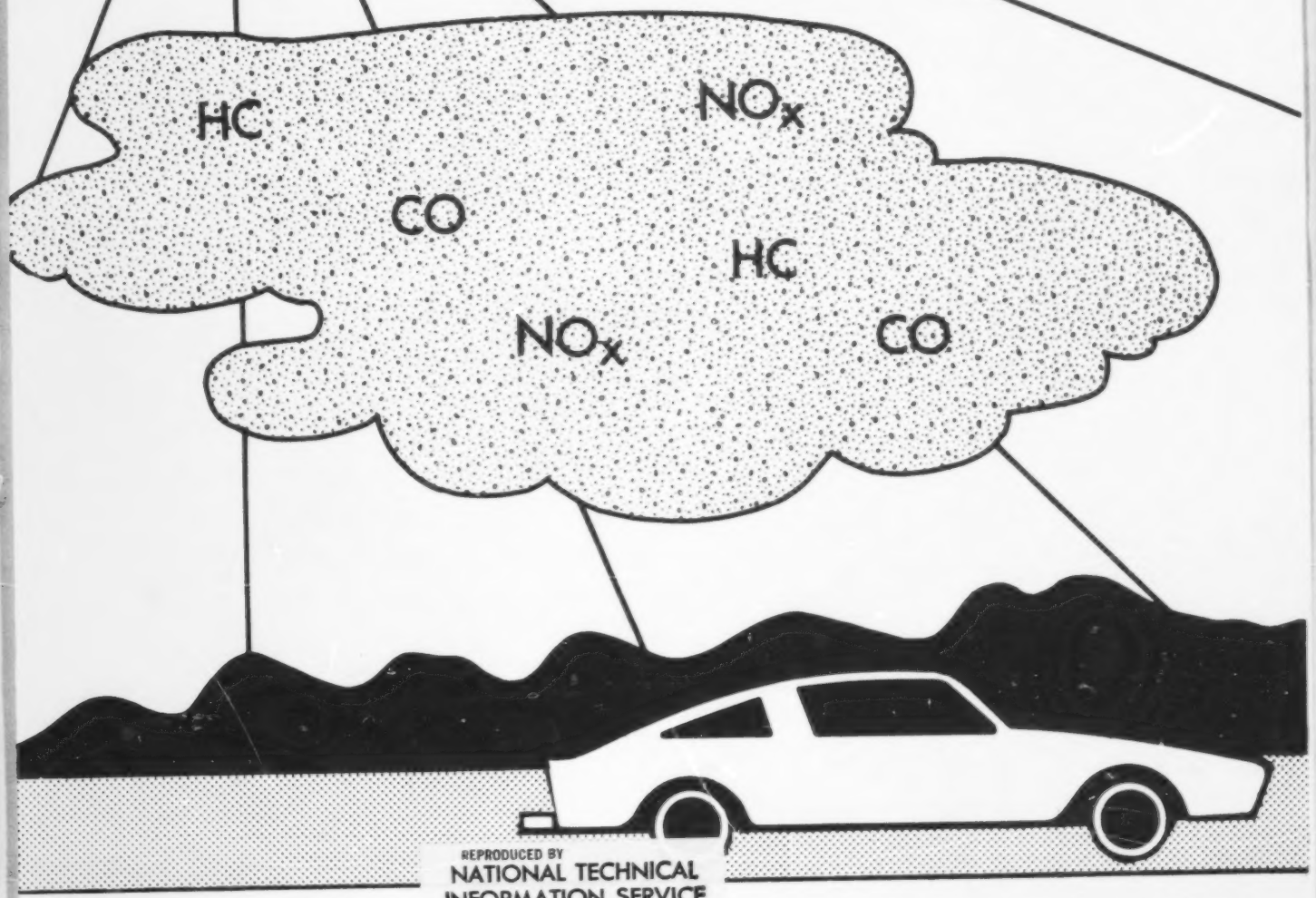
MOTOR VEHICLE EMISSIONS CONTROL BOOK SIX SPARK CONTROL SYSTEMS



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16. ABSTRACT

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. It is intended to assist the practicing mechanic or the home mechanic to better understand the Spark Control Systems which are an integral part of automobiles today. The mechanic's increased knowledge should help him keep "emissions controlled" vehicles operating as designed. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

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MOTOR VEHICLE EMISSIONS CONTROL
BOOK SIX
SPARK CONTROL SYSTEMS

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MOTOR VEHICLE EMISSIONS CONTROL

-- SERIES OF SEVEN BOOKS --

MOTOR VEHICLE EMISSIONS STAFF, COLORADO STATE UNIVERSITY

BOOK ONE - POSITIVE CRANKCASE VENTILATION SYSTEMS

BOOK TWO - THERMOSTATIC AIR CLEANER SYSTEMS

BOOK THREE - AIR INJECTION REACTION SYSTEMS

BOOK FOUR - FUEL EVAPORATION CONTROL SYSTEMS

BOOK FIVE - EXHAUST GAS RECIRCULATION SYSTEMS

BOOK SIX - SPARK CONTROL SYSTEMS

BOOK SEVEN - CATALYTIC CONVERTER SYSTEMS

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A special thanks must be extended to the automotive vehicle equipment and parts manufacturers for their cooperation and assistance in the development of this training material.

INSTRUCTIONS FOR THE USE OF THIS BOOK

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. Each book is designed to be used as self-instructional material. Therefore, it is important that you follow the step-by-step procedure format so that you may realize the full value of the emissions system which is being presented. The topics are taught in incremental steps and each topic treatment prepares the student for the next topic. Each book is divided into sections which include the introduction, purpose, function, inspection and testing of the emissions system presented.

As you proceed through this series, please begin with book one and read the following books in sequence. This is important because there are several instances where material covered in a given book relies on previously covered material in another book.

To receive the full benefits of the book, please answer the self-evaluation statements related to the material. These statements are separated from the text by solid lines crossing the page. The answers to the statement can be found at the end of the book as identified by the table of contents. You should check for the correct answer after you respond to each statement. If you find that you have made a mistake, go back through the material which relates to the statement or statements.

Fill-in-the-blank statements are utilized for self-evaluation purposes throughout the material. An example statement would appear like this:

The American flag is red, white, and _____.

You would write "blue" in the blank and immediately check your answer at the end of the book.

The material, statements and illustrations should be easy to follow and understand. In several illustrations a small ghost named "VEC" (Vehicle Emissions Control) has been used to make the picture easier to understand.

Upon completion of this series, you should be able to better understand the emissions control systems and devices which are an integral part of automobiles today. Your increased knowledge should help you keep these "emissions controlled" vehicles operating as they were designed to operate. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

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INTRODUCTION TO EMISSIONS CONTROL

As we all know emissions systems and devices have been installed on the automobile engine because of the air pollution problem. In order for you to understand these emissions systems and devices you should have a background of the problem. All of the emissions control systems were installed on the engine to reduce just three specific exhaust products. These are known as products of combustion. The three products which the emissions systems are designed to reduce are hydrocarbons, carbon monoxide and oxides of nitrogen.

HYDROCARBONS

Gasoline, like all petroleum products, is made up of hundreds of hydrocarbon compounds. The name "hydrocarbon" has been given to these compounds because they are made up of hydrogen and carbon atoms. This is also the reason hydrocarbons have the abbreviation (HC).

Hydrocarbons are gasoline vapors or raw gasoline itself. One reason hydrocarbon emissions must be controlled is because it is one of the major components of photochemical smog. Photochemical or "Los Angeles" smog forms when hydrocarbons and oxides of nitrogen combine in the presence of sunlight. In order to avoid this smog condition the hydrocarbon emissions from automobiles must be controlled. Hydrocarbons also act as an irritant to our eyes and some are suspected of causing cancer and other health problems.

CARBON MONOXIDE

Another product of combustion that must be controlled is carbon monoxide. Carbon monoxide has the abbreviation (CO). CO is also hazardous to our health when it is mixed with the air we breathe. It can cause headaches, reduce mental alertness and even cause death if enough of it is in the air. Carbon monoxide is also a problem in that it speeds the formation of photochemical smog. For these reasons CO emissions must be controlled.

OXIDES OF NITROGEN

Oxides of nitrogen are the last harmful products of combustion we will discuss. Nitrogen oxides have been given the abbreviation (NO_x). As you already know, oxides of nitrogen and hydrocarbons combine to form photochemical smog. The sunlight which triggers the formation of photochemical smog has another effect on oxides of nitrogen. Some of the oxides of nitrogen are broken down and a gas called ozone is formed. Ozone is a lung and eye irritant and it also deteriorates rubber and affects the growth of vegetation. Since the nitrogen oxides have these effects they must also be controlled.

Now that you are familiar with the emissions which must be controlled let's find out where they originate.

FORMATION OF HYDROCARBONS

Hydrocarbons, you will recall, are fuel vapors or raw fuel. For this reason hydrocarbon emissions will result from any uncontained supply of gasoline. Hydrocarbon emissions also come from the tailpipe. If the automobile engine could achieve "complete combustion," all of the unburned fuel or hydrocarbons would be used up. However, it is impossible for today's automobile engines to achieve "complete combustion." Any time the fuel mixture in the combustion chamber is not completely burned, some hydrocarbons will be emitted from the tailpipe. The two main reasons why hydrocarbons are not completely burned are because of engine misfire and "quench areas." When an engine misfire occurs, none of the raw fuel or hydrocarbons are burned. When this happens they are simply exhausted directly to the atmosphere. Quench areas are places in the combustion chamber where the flame goes out before the fuel is completely burned. Small cavities such as where the head gasket seals the cylinder head to the block is a quench area. Another quench area is located between the top of the piston and the first compression ring. These areas are sources of hydrocarbon emissions.

FORMATION OF CARBON MONOXIDE

Carbon monoxide is partially burned fuel. Carbon monoxide is formed in the combustion chamber whenever there is not enough air to burn all the fuel. This means that whenever a "rich" air/fuel mixture is pulled into the combustion chamber carbon monoxide will be formed. After the flame goes out the carbon monoxide is exhausted through the tailpipe and into the air.

FORMATION OF OXIDES OF NITROGEN

Oxides of nitrogen are also formed in the combustion chamber. These oxides result from the nitrogen which is contained in our air. In some cases combustion temperatures in the automobile engine can exceed 4500°F. At temperatures above approximately 2500°F, nitrogen oxides will start forming. Therefore, if combustion chamber temperatures exceed 2500°F, oxides of nitrogen will be produced and then exhausted to our atmosphere.

Now that you understand how these emissions are formed in the automobile engine, we will see how changes in ignition timing and carburetor adjustment affect the amount of these pollutants.

As you know, changes in timing and carburetion can have a large effect on how an engine performs. These changes in timing and carburetion also can have drastic effects on the amount of pollutants which are present in the automobile's exhaust. The amount of hydrocarbons, carbon monoxide and oxides of nitrogen which are present in the exhaust gases will vary as timing and carburetion adjustments are changed.

IGNITION TIMING

Prior to emissions controlled automobiles, advancing the spark timing was a common practice. Setting the spark timing this way caused the spark plug to fire before the piston reached top dead center. This advanced spark timing allowed the maximum amount of heat energy to be

exerted on the piston. As a result the best performance and fuel economy could be obtained. Unfortunately, this also produced high hydrocarbon and nitrogen oxide emissions levels.

In order to reduce emissions levels, ignition spark timing was retarded. By firing the spark plug after the piston reaches top dead center, not as much of the heat energy is converted to work on the piston. The extra heat energy which is not used on the piston now passes through the exhaust valve and into the exhaust manifold. This keeps the exhaust gas temperatures higher. These higher exhaust temperatures allow burning of the air/fuel mixture to continue in the exhaust manifold. This further oxidation or burning in the exhaust manifold helps to reduce HC and CO emissions.

Another advantage of retarded timing from an emissions standpoint is that combustion temperatures are not as high. This is due to the fact that the maximum combustion pressure will be lower. Since the combustion temperatures will be lower and the formation of oxides of nitrogen depends on temperature, a smaller amount of these pollutants will be exhausted to the atmosphere.

There is one more advantage to using retarded spark timing. As you know, when ignition timing is retarded the engine's idle speed will drop. This decrease in idle speed occurs because less heat energy is applied to the combustion chamber and more heat energy is being supplied to continue the burning process in the exhaust manifold. In order to regain an acceptable idle speed, the throttle plates must be opened wider. This wider throttle plate opening allows more air to pass through the carburetor. This increase in air flow will reduce the amount of residual exhaust gases in the cylinder This in turn will allow a more burnable mixture which can be made leaner. Since the mixture can be leaner there will be more air in the combustion chamber. As you know, the more air that is made available during combustion the lower will be the HC and CO emissions.

CARBURETION

Adjustments made to the carburetor air/fuel ratio can also have a large effect on the amount of pollutants which come from the automobile engine. When idle mixture settings become richer there is less air present for the combustion process. This lack of air results in an increase in hydrocarbon and carbon monoxide emissions.

When idle mixture screws are turned in, the amount of fuel is reduced and the mixture becomes leaner. This leaner mixture contains more air and therefore more oxygen is available for more complete burning of the fuel. This results in lower HC and CO emissions levels.

As the idle mixture screws are turned in, the idle air/fuel mixture becomes leaner. If this mixture becomes too lean a "lean misfire" will occur. A "lean misfire" will occur because the fuel is so diluted or thinned out by the air that the mixture will not ignite. This leads to a very large increase in hydrocarbon emissions. This happens because the failure of the mixture to ignite results in that amount of raw fuel being emitted to the atmosphere.

The carbon monoxide emissions decrease when a lean misfire condition is present. Carbon monoxide is partially burned fuel. Since no combustion takes place during a lean misfire condition no CO is formed and the total amoung of CO produced by the engine will be less.

A lean misfire usually occurs in one or more cylinders. This condition may also move from cylinder to cylinder while the engine is running. This is caused by the uneven distribution of the air/fuel mixture delivered to each cylinder. This condition occurs mainly because of problems with intake manifold design.

Now you should understand how changes in timing and carburetion adjustment can affect emissions levels. With this knowledge you will be able to understand how each emissions control system we will discuss helps to reduce the air pollution caused by the automobile.

SYSTEM INTRODUCTION

In the introduction of this book you learned that photochemical smog was formed when oxides of nitrogen and hydrocarbons combine in the presence of sunlight. You have also learned about the emissions control systems which reduce the hydrocarbon emissions, as well as the EGR system used to reduce the oxides of nitrogen (NO_x) emissions. It is now time for you to learn about the spark control system. This system, like the EGR system, is designed to help reduce oxides of nitrogen or NO_x emissions. It also helps to reduce hydrocarbon emissions.

Spark control systems as we know them today first began to appear on automobile engines in the very late 1960's and early 1970's. As with many of the other systems we have discussed, the spark control system is not installed on all automobile engines. The spark control system was installed on those vehicles needing it to meet federal regulations. A large number of American and foreign automobiles are equipped with a spark control system.

The spark control system helps to reduce the amount of oxides of nitrogen emitted from the automobile's tailpipe. As you recall from the introduction, oxides of nitrogen are formed in the combustion chamber. The spark control system is designed to lower the amount of NO_x which is formed during the combustion process. Since less amounts of NO_x are formed in the combustion chamber, there is less NO_x which will be emitted from the tailpipe. This in turn will help to reduce the formation of photochemical smog.

In addition, the spark control system helps reduce hydrocarbon emissions. Unlike the reduction of NO_x emissions, the HC emissions are controlled or reduced after they leave the combustion chamber. These hydrocarbons are burned in the exhaust manifold after they leave the combustion chamber. By reducing the HC emissions the spark control system helps to control the other important component of photochemical smog. This system reduces both HC and NO_x.

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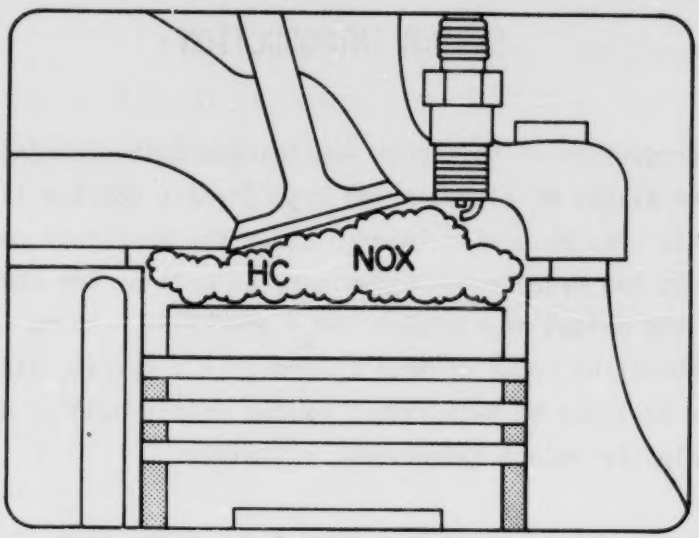

FIGURE 6-1

The period when the most oxides of nitrogen and hydrocarbons are emitted from the tailpipe is when the engine is under a heavy load. When a vehicle is accelerating, climbing hills or towing a trailer the engine will be in a loaded condition. When the engine is loaded in this manner, the air/fuel ratio entering the combustion chamber will be relatively rich. This rich condition will raise the HC emissions. The throttle plates will also be opened fairly wide when the engine is under load. With these conditions the combustion chamber pressures and temperatures will be high. As you recall from the introduction, oxides of nitrogen are formed when high temperatures in the combustion chamber occur. Now that you have a basic understanding of when the larger amounts of HC and NO_x are formed, we will take a look at how they are controlled.

The spark control system actually controls the ignition timing of the engine. This system will prevent the vacuum advance from operating under certain engine conditions. By preventing vacuum advance the spark plug will fire later in the compression stroke. When this occurs, not as much heat energy will be exerted on the piston. The extra heat energy will be released in the exhaust manifold during the exhaust stroke.

Since preventing vacuum advance causes less heat energy to be exerted on the piston the combustion chamber temperatures will be lower. You know that the formation of oxides of nitrogen depends on high temperatures. Since the combustion temperatures are reduced with the use of a spark control system, the formation of NO_x will be reduced. This is how the spark control system reduces oxides of nitrogen.

Preventing vacuum advance also causes the exhaust gas temperature to increase Since there is a higher exhaust gas temperature, the hydrocarbons will continue to burn or oxidize in the exhuast manifold. Preventing vacuum advance will also cause the idle RPM to drop. By opening the throttle plates wider the idle speed can be brought back to an acceptable level. This will allow additional air into the combustion chamber and aid in further oxidizing the hydrocarbons. So you can now see that the additional air and the hotter exhaust temperatures will lower the HC emissions.

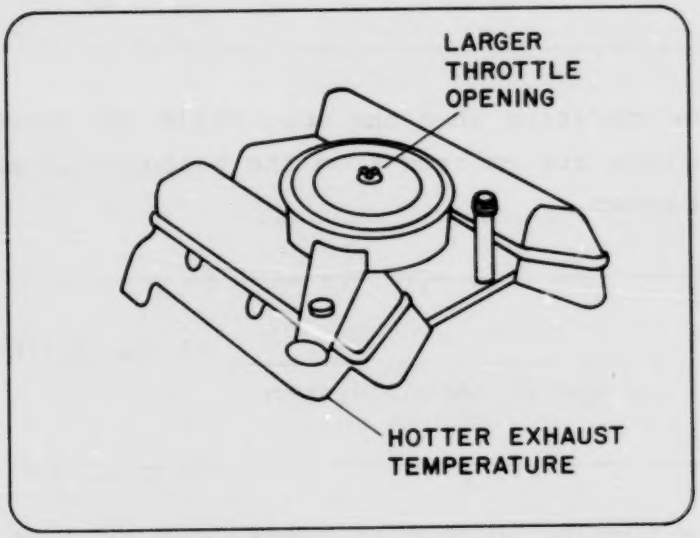

FIGURE 6-2

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1. The spark control system aids in reducing the amount of _____ ____ _____ emitted from the automobile's tailpipe.

---

2. The spark control system is designed to lower the amount of NO_x which is formed during the _____ _____.

3. _____ _____ are also reduced by the spark control systems.

4. The hydrocarbons are controlled by burning in the _____ _____ after they leave the combustion chamber.

5. The condition when the most oxides of nitrogen and hydrocarbons are emitted from the tailpipe is when the engine is under _____ _____.

6. _____ _____ of the engine is controlled by the spark control system.

7. The combustion chamber temperature will be lower when vacuum advance is denied. This causes less heat energy to be exerted on the _____.

8. _____ _____ temperatures increase when vacuum advance is denied.

You should now have a basic understanding of how the spark control system controls hydrocarbons and oxides of nitrogen. It is now time to study the purpose of the components in the spark control system and how they work.

SYSTEM/COMPONENT PURPOSE

The purpose of any spark control system is to prevent or delay distributor vacuum advance during certain periods of engine operation. By preventing advanced spark timing, oxides of nitrogen and hydrocarbon emissions will be reduced. The greatest amount of oxides of nitrogen and hydrocarbons are produced when the engine is under a heavy load. Therefore, the purpose of the spark control system is to prevent advanced ignition spark during periods of heavy engine load. An automobile engine can achieve better fuel economy if it has an advanced ignition spark. For this reason, the spark control system must provide an advanced spark when the automobile is cruising and the engine is not heavily loaded.

In our discussion of the spark control system, we will first look at some individual components used in this system. Once you know the purpose of these components, we will look at how they work together as a system.

VACUUM SOLENOID VALVE

The first component we will discuss is the vacuum solenoid valve. Figure 6-3 shows a typical vacuum solenoid valve found in many spark control systems.

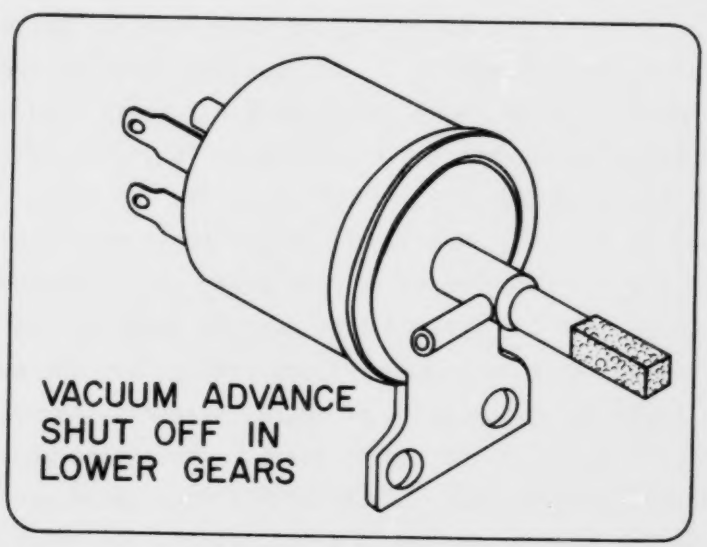

FIGURE 6-3

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The purpose of the vacuum solenoid valve is to block or prevent vacuum from reaching the vacuum advance unit on the distributor. This in done only when the engine is accelerating from low speeds. When the automobile is at cruising speed the vacuum solenoid valve will allow vacuum to reach the advance unit on the distributor. The vacuum solenoid valve has one other job to do. This is to vent air into the vacuum advance unit whenever the solenoid denies vacuum.

The vacuum solenoid valve is triggered to allow or deny vacuum advance by an electrical circuit. This electrical circuit is controlled by a switch on the transmission.

---

9. An _____ _____ spark will allow an automobile engine to achieve better fuel economy.

TRANSMISSION SWITCH

The next component in the spark control system we will look at is the transmission switch. You know that the spark control system prevents vacuum advance when the engine is accelerating from low speeds. The automobile manufacturers found that nearly all heavy load operation of the automobile occured when the transmission is in the lower gears. For this reason if vacuum advance was denied in all the lower gears, the NO_x and HC could be reduced. Nearly all of the cruising engine operation occurs when the transmission is in high gear. So if vacuum advance was allowed in high gear the desired fuel economy could be obtained at cruising speeds. This is how many spark control systems work. On a car with a three speed automatic or manual transmission, vacuum advance will be blocked in first and second gears. The engine would be allowed vacuum advance in third gear. A car with a four speed manual transmission will have vacuum advance denied in first, second and third gears and it would be allowed vacuum advance in fourth gear. The transmission switch

and the vacuum solenoid valve are the components of the spark control systems which make this happen.

Figure 6-4 shows two transmission switches. These are electrical switches which are connected to the transmission. The electrical circuit through the switch can either be open or closed.

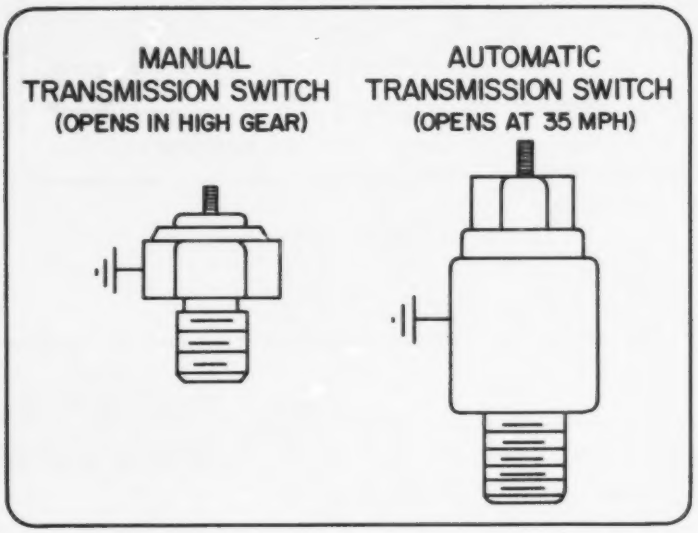

FIGURE 6-4

When the switch is open, no current will flow through the circuit. When the switch is closed, current will pass through the switch and the rest of the circuit. The purpose of the transmission switch is to control the operation of the vacuum solenoid valve. It is connected to the transmission so it will switch positions and trigger the vacuum solenoid valve when the transmission shifts into high gear. In this manner, the transmission switch and the vacuum solenoid valve will allow vacuum advance only in high gear. Figure 6-5 shows how these components are connected together in the system.

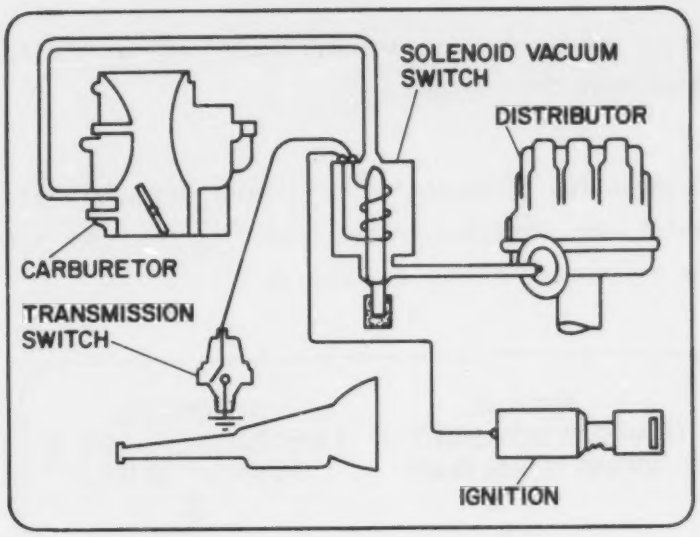

FIGURE 6-5

10. The _____ _____ valve's purpose is to block or prevent vacuum from reaching the vacuum advance diaphragm on the distributor.

11. An _____ _____ triggers the vacuum solenoid valve to allow or deny vacuum advance.

12. A switch on the _____ controls the electrical circuit.

13. On a car with a three speed automatic transmission, vacuum advance will be blocked in both _____ _____ _____ gears.

14. The purpose of the transmission switch is to control the operation of the _____ _____ valve.

COLD CTO SWITCH

Automobile manufacturers found that this spark control system worked well most of the time. However, when the engine was cold, the automobile suffered from driveability problems if vacuum advance was denied by the system. For this reason a cold temperature override or CTO switch was added to the system. This switch improved cold engine driveability. A CTO switch is shown in figure 6-6..

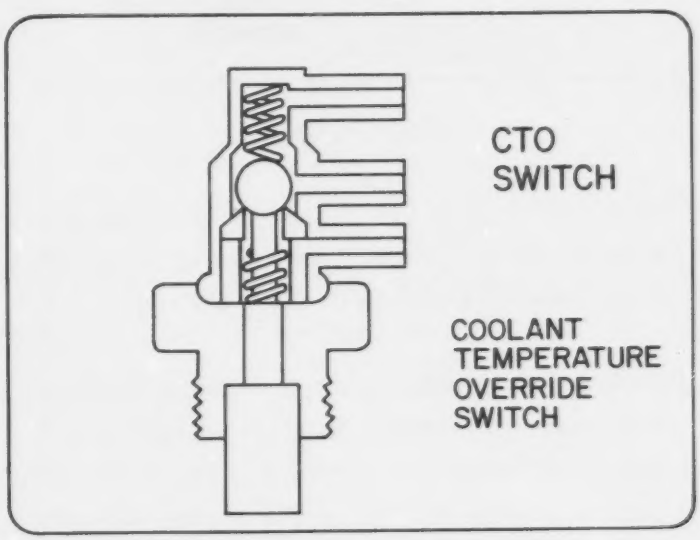

FIGURE 6-6

The purpose of the cold temperature override or CTO switch, is to allow full manifold vacuum to the vacuum advance unit when the engine is cold.

HOT CTO SWITCH

There is also a hot coolant temperature override switch built into the spark control system on some automobiles. This switch is called a hot override. Figure 6-7 shows a hot override switch.

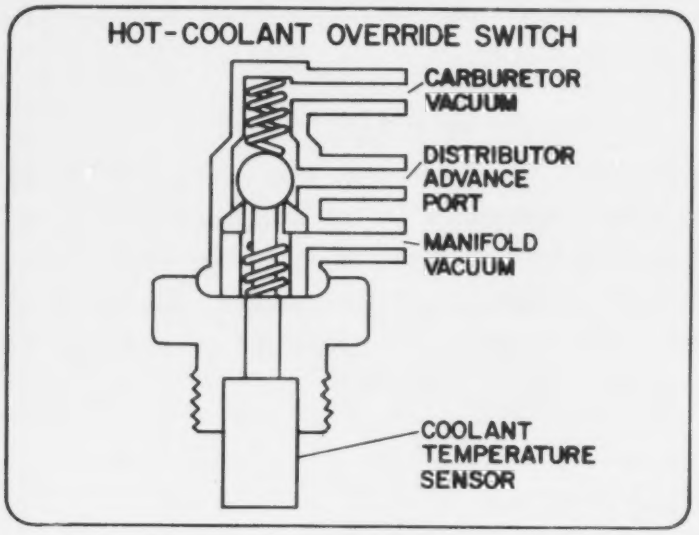

FIGURE 6-7

This switch looks just like a CTO swtich. The purpose of the hot override switch is to allow full manifold vacuum to reach the advance unit on the distributor when the engine becomes too hot.

As you probably know, the vacuum used to advance the spark on most newer cars is ported vacuum. This means that the vacuum signal is picked up from a small port just above the throttle plate. For this reason, there is no ported vacuum at idle and no vacuum advance at idle. However, the CTO and hot override switches direct full manifold vacuum to the advance unit when the engine is either too cold to too hot. This manifold vacuum will immediately advance the spark. This will cause the idle RPM to increase which will result in more efficient cooling for the hot engine and will allow a faster warm-up for the cold engine. When the engine reaches a normal operating temperature after being either too cold or too hot the override switch will again direct ported vacuum to the advance unit.

15. To improve cold engine driveability, a _____ _____ _____ switch has been installed in the transmission control spark system.

16. The purpose of the CTO switch is to allow _____ _____ to the vacuum advance unit on the distributor when the engine is cold.

17. The purpose of the _____ _____ switch is to allow full manifold vacuum to reach the advance unit on the distributor when the engine becomes too hot.

ESC SOLENOID VACUUM CONTROL VALVE

Another spark control system called the ESC or Electronic Spark Control system has components which do the same job as those we have just discussed. The first component of this system we shall discuss is the solenoid vacuum control valve. This valve may be seen in figure 6-8. The purpose of the

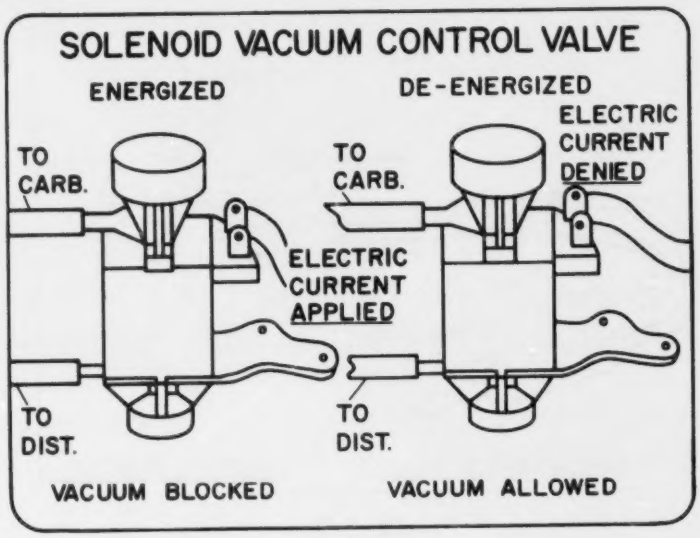

FIGURE 6-8

solenoid vacuum control valve is exactly the same as the vacuum solenoid valve which we discussed. The purpose of both solenoid valves is to deny or prevent vacuum from reaching the advance unit on the distributor. When either of these valves are denying vacuum advance they will also vent the line which connects to the advance unit on the distributor. This will assure the removal of the extra advance provided by the distributor vacuum advance unit. Remember that the solenoid valves deny vacuum advance only when the engine is accelerating from low speeds.

18. Another spark control system called the _____ _____ Control system has components which do the same job as the other spark control systems.

19. When the engine is _____ from low speeds the solenoid valve denies vacuum advance.

SPEED SENSOR

Figure 6-9 shows the next component of this spark control system we will

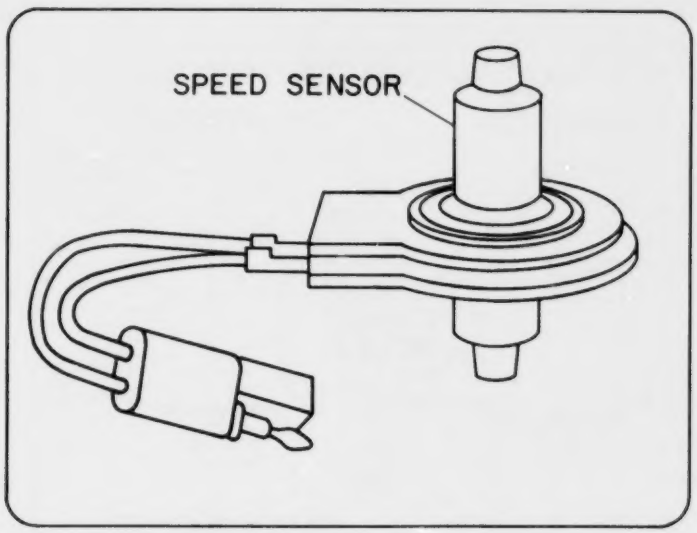

FIGURE 6-9

discuss. This component is the speed sensor. The speed sensor's purpose is to generate a small voltage signal. The speed sensor is connected to the speedometer cable and senses how fast the automobile is moving. The voltage signal produced by the speed sensor increases as the vehicle speed increases.

ELECTRONIC AMPLIFIER

The speed sensor signal is sent to an electronic amplifier. Two electronic amplifiers are shown in figure 6-10.

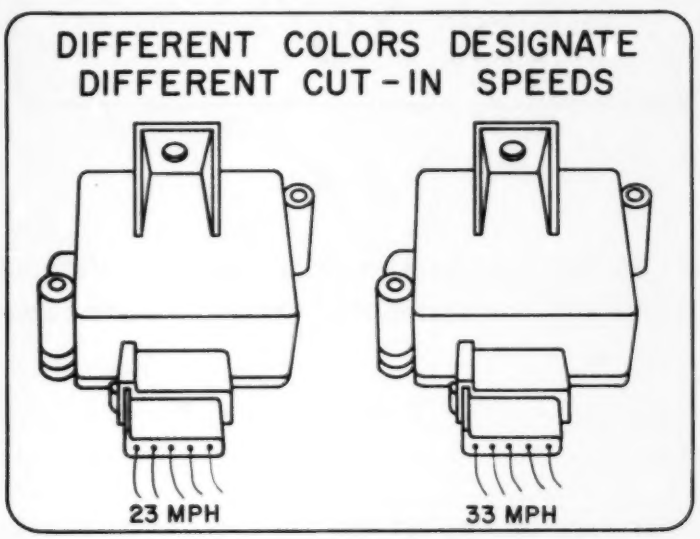

FIGURE 6-10

The purpose of the electronic amplifier is to control the solenoid vacuum valve's operation. The electronic amplifier will trigger the solenoid vacuum valve to either allow or deny vacuum to the vacuum advance unit on the distributor. The electronic amplifier determines when to do this by the signal received from the speed sensor.

AMBIENT TEMPERATURE SWITCH

This ESC system also has an ambient temperature switch to help cold engine driveability. This temperature switch is shown in figure 6-11. The purpose of the ambient temperature switch is to override the ESC

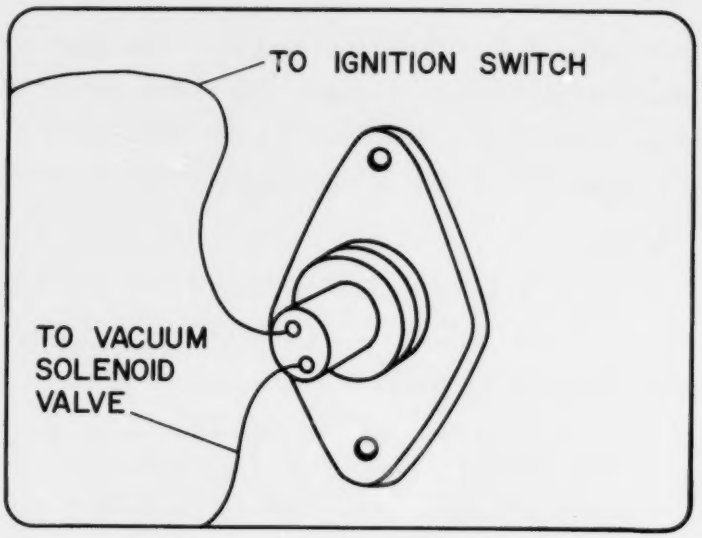

FIGURE 6-11

system and allow full vacuum advance to reach the distributor. This switch will override the system when the outside air temperature is below 50°F.

---

20. The purpose of the speed sensor is to generate a small _____ _____.

---

21. The _____ _____ purpose is to control the solenoid vacuum valve operation.

TRS TRANSMISSION SWITCH

Another system called the TRS or Transmission Regulated Spark system is very similar to the ESC system. This system, however, uses a transmission switch instead of the speed sensor and the electronic amplifier. The

purpose of the transmission switch, as you should recall, is to trigger the solenoid vacuum valve to either allow or deny vacuum to pass on to the distributor vacuum advance unit.

SPARK DELAY VALVE

Another very simple spark control system is the spark delay system. There is only one component in this system. This component is the spark delay valve. This valve is shown in figure 6-12. The purpose of the

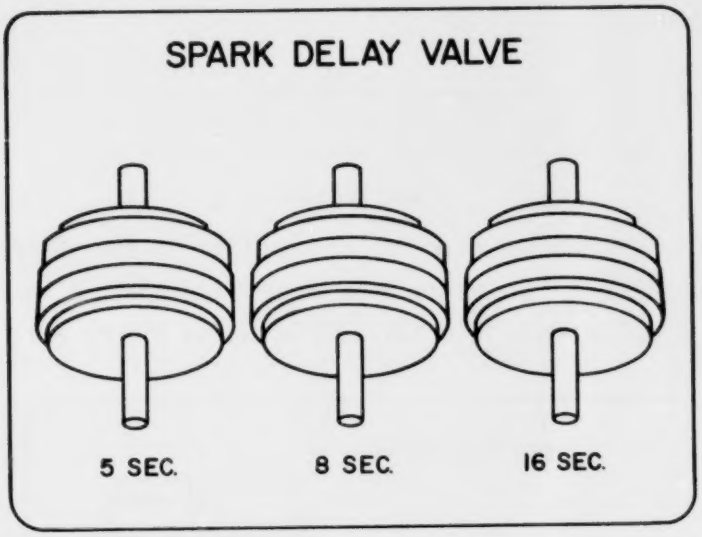

FIGURE 6-12

spark delay valve is to simply delay the vacuum from reaching the vacuum advance unit on the distributor. Whenever the vacuum advance signal drops to approximately 0" Hg, the valve will vent the vacuum line and the vacuum advance will be denied. This will occur whenever the throttle plates are closed or fully open. When the vacuum advance signal again increases, the spark delay valve will delay this vacuum signal from reaching the advance unit for a few seconds. After a few seconds vacuum advance will be allowed.

22. TRS stands for _____ _____ _____ system.

23. Instead of using the speed sensor and electronic amplifier the TRS system uses a _____ switch.

OSAC VALVE

The last spark control system is very similar to the spark delay system we just discussed. The system uses an Orifice Spark Advance Control Valve or (OSAC) valve. This valve is shown in figure 6-13.

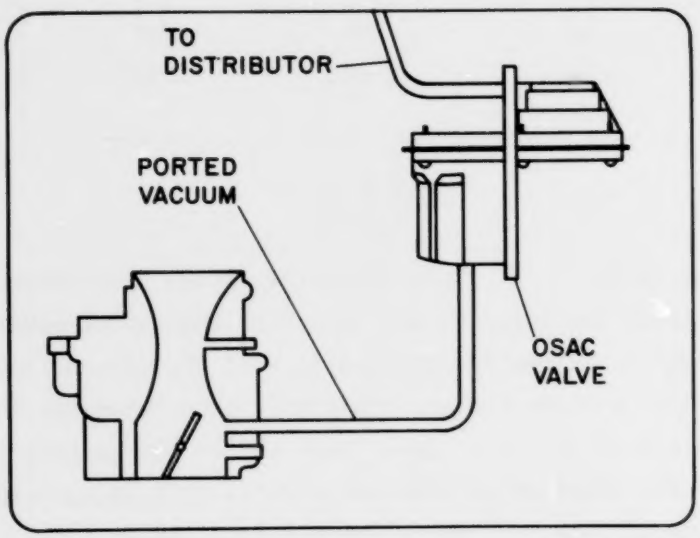

FIGURE 6-13

The OSAC valve is very similar to the spark delay valve. The purpose of the OSAC valve is to delay the vacuum signal from reaching the distributor vacuum advance unit for a few seconds. This valve works in the same

manner as the spark delay valve. The OSAC valve may however, have a temperature control unit built into its housing. The temperature control unit simply by-passes the delay portion of the valve when the air temperature is below 60°F. When the air is below 60°F the vacuum signal is not delayed but is allowed to the advance diaphragm immediately.

---

24. The _____ _____ system is another very simple spark control system.

---

25. The purpose of the spark _____ _____ is to delay the vacuum from reaching the vacuum advance unit on the distributor.

---

26. OSAC stands for _____ _____ _____ _____.

---

27. The purpose of the OSAC valve is to delay the vacuum signal from reaching the _____ _____ diaphragm for a few seconds.

Now you should be aware of the purpose of the various spark control system components. We will now move on to the function of these components and the systems themselves.

SYSTEM/COMPONENT FUNCTION

In the purpose section of this book you learned about the components of the spark control system. You should be familiar with the job each of the components must do. In this section we will take a look at how these components do their jobs. Once you know how each component does its job, you will learn how these components work together in the spark control system.

VACUUM SOLENOID VALVE

The vacuum solenoid valve is the first component we will discuss. As you recall the purpose of the vacuum solenoid valve is to allow or prevent vacuum from reaching the advance unit on the distributor. It must also vent the line to the advance unit when the vacuum is being denied.

Figure 6-14 shows the inside of a typical vacuum solenoid valve. As you can see in figure 6-14, inside the main body of the vacuum solenoid valve is a wire coil and a small rod. On the outside of the vacuum solenoid

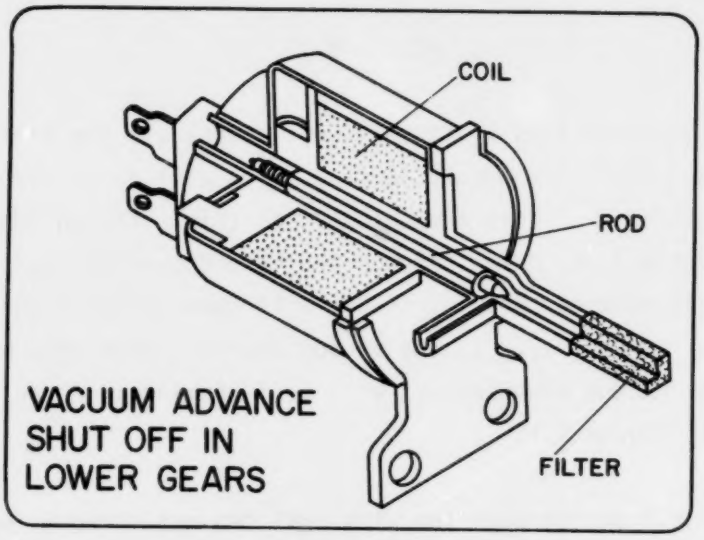

FIGURE 6-14

valve are two electrical terminals. There terminals are connected to both ends of the wire coil. When current flows through the wire coil, a

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magnetic field will be produced. This magnetic field will collapse or disappear when the current is removed from the wire coil.

The small metal rod inside the vacuum solenoid valve moves in the magnetic field created by the wire coil. When no current is flowing through the wire coil, the metal rod will be in the position shown in figure 6-15.

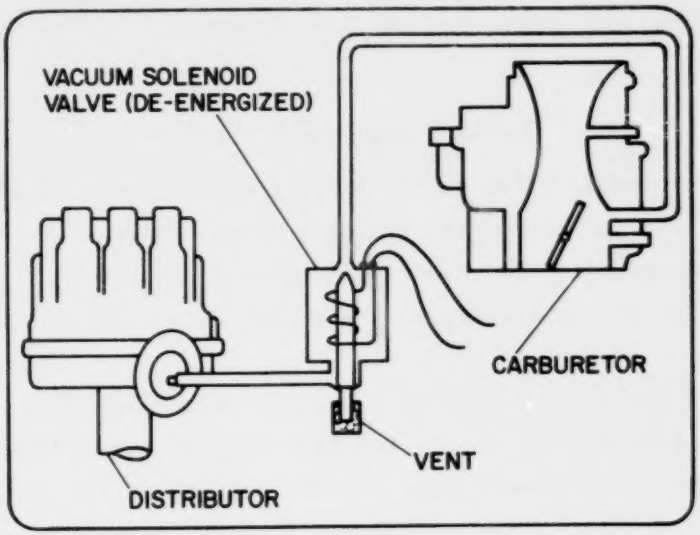

FIGURE 6-15

When the rod is in this position it will block off the filtered vent passageway. This is the position the valve will be in when it is allowing vacuum advance. When the valve is in this position the air in the advance unit will be drawn through the hose connection which connects the valve to the advance unit. This air will then be drawn past the metal rod and out of the valve to the vacuum source. Once this air has been removed the vacuum advance unit will be in the advanced position. This is shown in figure 6-15.

When current flows through the wire coil the metal rod is pulled to the carburetor end of the valve. In this position, the filtered vent will allow air to pass through the valve and into the advance unit. This will eliminate all spark advance caused by the vacuum advance unit. The end of the metal rod will also block the vacuum source hose connection and prevent any vacuum from moving beyond the valve.

The flow of current through the vacuum solenoid wire coil is controlled by the automobile's ignition switch and the transmission switch. These switches are connected in a series circuit. For this reason both switches must be closed to complete the circuit and energize the vacuum solenoid valve. Whenever the ignition switch is in the engine run position it is closed. For this reason the transmission switch is what controls the vacuum solenoid valve.

28. Located inside the main body of the vacuum solenoid valve is a small rod and a _____ _____.

29. Two _____ _____ are located on the outside of the vacuum solenoid valve.

30. The small metal rod inside the vacuum valve moves in the _____ _____ created by current flow in the wire coil.

31. When _____ flows through the wire coil the metal rod is pulled to one end of the valve.

32. The automobile's _____ _____ and the transmission switch control the flow of current through the vacuum solenoid wire coil.

33. The ignition and transmission switches are connected in a _____ circuit.

TRANSMISSION SWITCH

The transmission switch, vacuum solenoid valve, and the ignition switch are connected together as shown in figure 6-16. The transmission switch is an on-off switch. This means that it can only be open or closed or that it can only block or pass current.

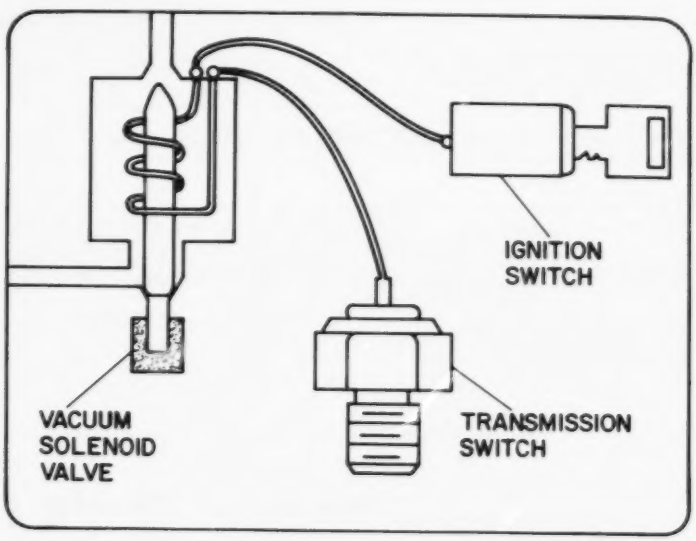

FIGURE 6-16

The transmission switch used for automobiles equipped with automatic transmissions is connected into the hydraulic circuit of the transmission. This switch senses hydraulic pressure in the transmission. Figure 6-17 shows when the switch is open or closed. As you can see in figure 6-17, the switch will open and block current flow when the automobile speed reaches 35 MPH or higher. The switch will be closed and pass current whenever the automobile is moving slower than 35 MPH. The transmission

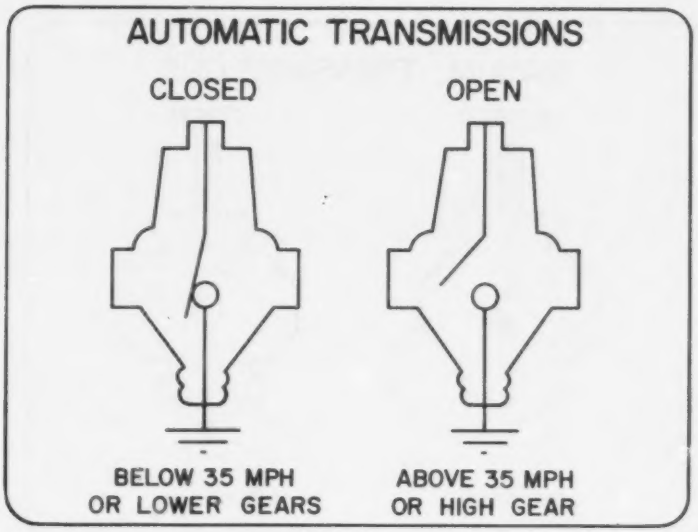

FIGURE 6-17

switch knows how fast the automobile is moving because it senses hydraulic pressure in the transmission. The end of the transmission switch which connects to the transmission has a small pressure sensor built into it. As the speed of the automobile changes, the hydraulic pressure changes. When the automobile reaches a speed of approximately 35 MPH, the hydraulic pressure will change to the point where it will trigger the sensor, which in turn will open the electrical part of the switch. When this happens, current can no longer flow through the transmission switch and the vacuum solenoid valve will de-energize. As you already know, when this happens vacuum will be allowed to the vacuum advance unit on the distributor.

The transmission switch used on automobiles equipped with manual transmissions are very similar to the automatic transmission switch. The manual transmission switch however, is not triggered by a pressure sensor. The manual transmission switch is mounted on the transmission so when the automobile is shifted into high gear the shift linkage comes in contact with the switch. Figure 6-18 shows the electrical condition of the switch when the transmission is in the lower gears and when it is in high gear. As you can see when the transmission is in the lower gears, the linkage is

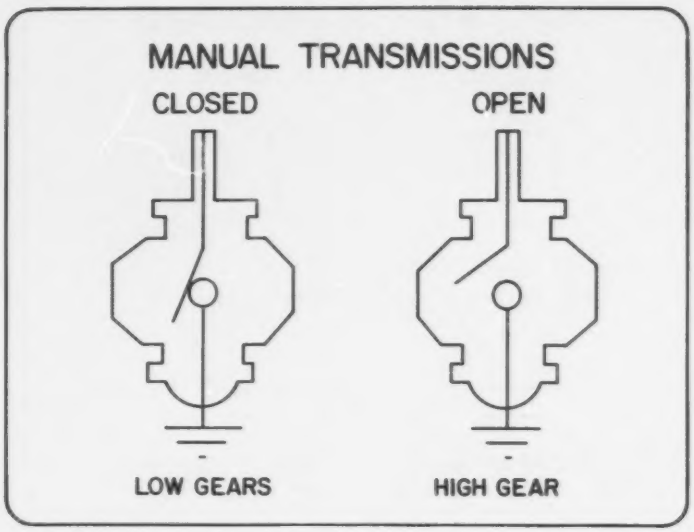

FIGURE 6-18

not in contact with the switch. In this position the switch will remain closed and current will pass through the switch. This will energize the vacuum solenoid valve and block the vacuum signal from reaching the advance unit. However, when the transmission is shifted to high gear, the shift linkage will contact the transmission switch. This will open the switch and stop the current flow through the circuit. As you know, when this current flow stops, the vacuum solenoid valve de-energizes and the engine is allowed vacuum advance.

34. The _____ switch is an on-off switch.

35. The transmission switch used with automatic transmissions knows how fast the automobile is moving because it senses _____ _____ in the transmission.

36. The manual transmission switch is triggered by physical contact with the shift _____.

37. The vacuum solenoid valve will be _____ when the transmission switch is open.

SPARK CONTROL SYSTEM

Now you should understand the function of the vacuum solenoid valve and the transmission switch circuit. You probably understand how they work together to prevent or allow vacuum advance. However, we will now look at these components in the system and see how they work together.

Figure 6-19 shows this spark control system with the automobile in high gear or above 35 MPH. As you know, when the automobile is traveling at this speed, the transmission switch is open. This is shown in figure 6-19. When the switch is open the vacuum solenoid valve will be de-energized.

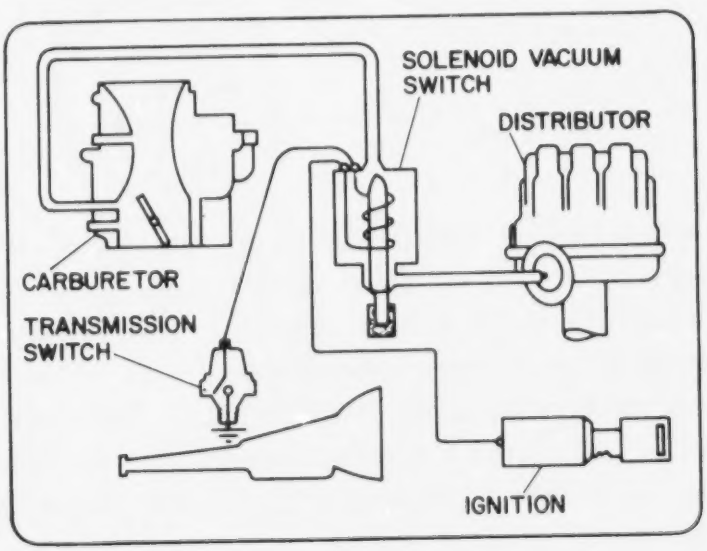

FIGURE 6-19

As you can see in figure 6-19, when the valve is de-energized, the valve rod moves down and seals the filtered vent on the end of the vacuum solenoid valve. In this position, the vacuum will pass through the valve by going around the metal rod. It will then move on to the distributor vacuum advance unit. The system, when it is in this position, will allow vacuum advance.

Figure 6-20 shows the spark control system when the vehicle is in a lower gear or below 35 MPH. When the vehicle is traveling at this lower speed, the transmission switch will be closed and current will flow through the circuit. As you can see in figure 6-20, when current flows through the

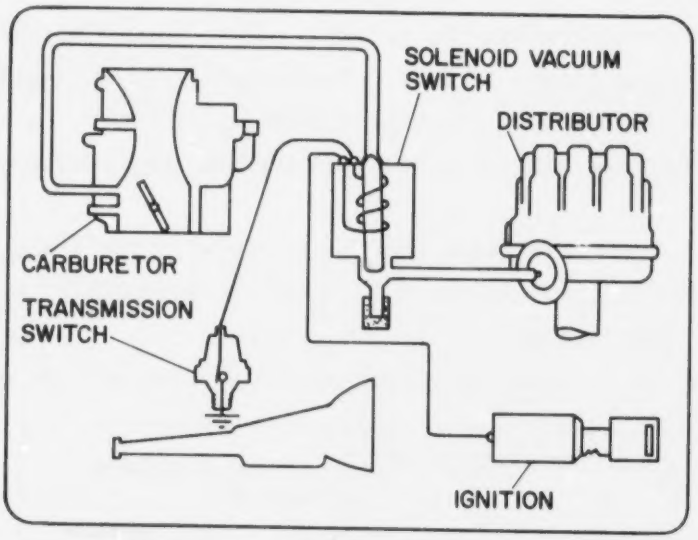

FIGURE 6-20

circuit the metal rod will be pulled to the opposite end of the vacuum solenoid valve. This rod will seat against the upper connection of the valve and block the vacuum at that point. In this position, the engine will be denied vacuum advance. When the rod moves to the opposite end of the valve the filtered vent will be exposed. When this happens, outside air will move into the valve, connecting line, and vacuum advance unit. This can be seen in figure 6-21. For this reason the engine will be permitted no vacuum spark advance

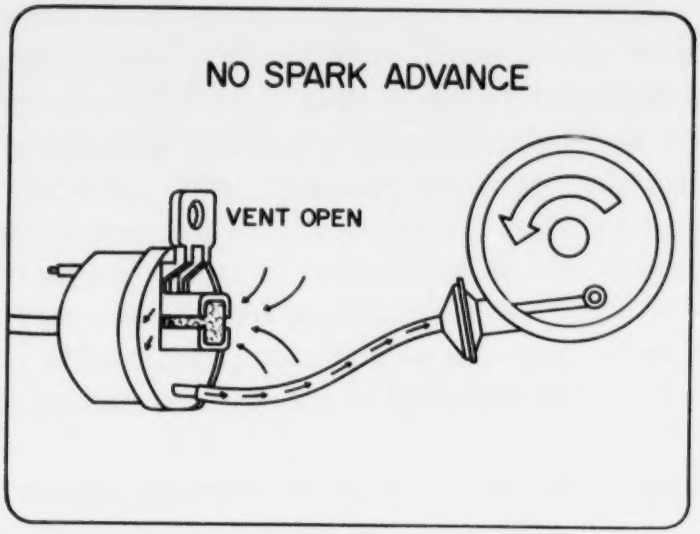

FIGURE 6-21

COLD CTO SWITCH

The next component of this spark control system we will look at is the CTO or coolant temperature override switch. Figure 6-22 shows a cut-away view of a CTO switch. The CTO switch is mounted in such a way that the lower portion of the switch is in contact with the engine coolant. This is how a CTO switch senses coolant temperature. As you can see in figure 6-22, the CTO switch has three hose connections on the switch body.

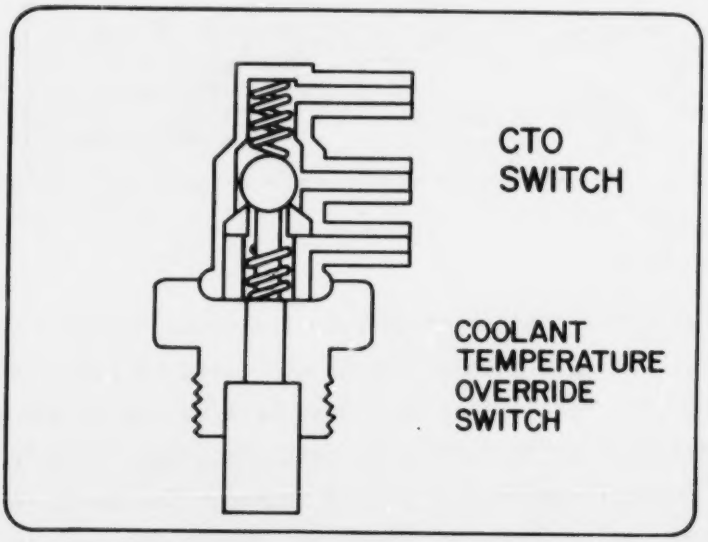

FIGURE 6-22

Inside the switch body is a small ball and a spring. One other important substance is in the CTO switch which you can't readily see. This substance is a heat-sensitive paste which controls the operation of the CTO switch. This heat-sensitive paste will expand as it takes on heat from the engine coolant. As this paste expands it will push the ball up against spring pressure. In this way, when the paste is cold and contracted, the ball will be in the lower portion of the switch body. When the paste is hot and has expanded, the ball will be in the upper part of the valve body. Now we will look at how the CTO switch is used to further control the operation of the spark control system.

Figure 6-23 shows how the CTO switch is connected into the spark control system we have been discussing. As you can see in figure 6-23, the upper hose connection of the CTO switch is connected to a manifold vacuum

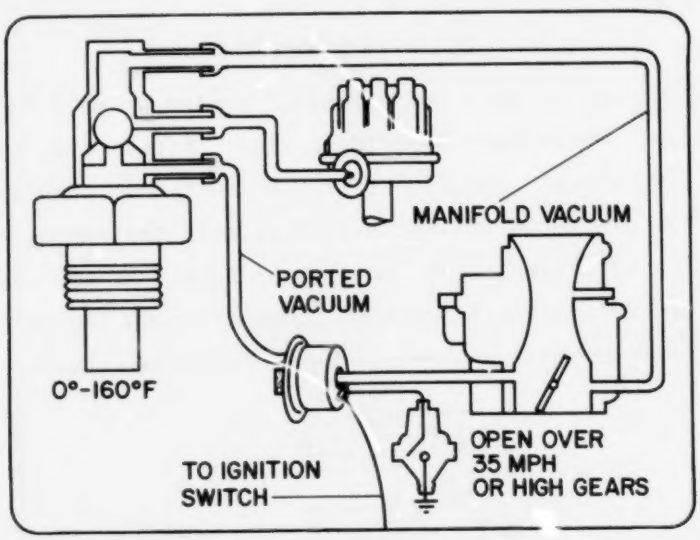

FIGURE 6-23

source. The middle connection goes to the vacuum advance unit on the distributor. The lower connection is connected to the solenoid vacuum switch. You will recall that this hose went to the vacuum advance unit on the distributor on the system we just discussed. Figure 6-23 shows this spark control system with a cold engine. The paste in the CTO switch is cold and contracted. For this reason the ball is in the lower portion of the switch body.

When the CTO switch is in this position, the manifold vacuum signal is allowed to pass to the spark advance unit on the distributor. This may be seen in figure 6-23. Since the engine is cold this will aid drive-ability and help warm the engine more quickly.

As the engine coolant approaches approximately 160°F, the paste in the CTO switch will be fully expanded and the ball will be in the upper portion of the switch body. This condition is shown in figure 6-24.

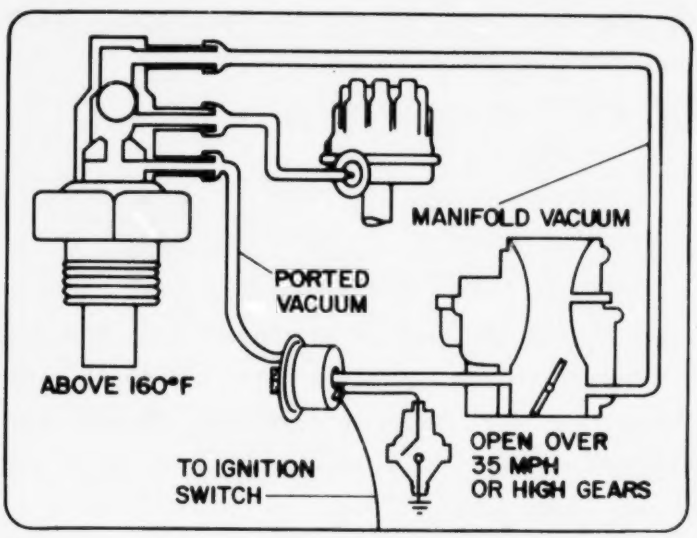

FIGURE 6-24

When the CTO switch is in this position, the spark control system will operate exactly as the first spark control system we discussed. Figure 6-24 shows the system when the automobile is in high gear. With this condition, the vacuum signal will pass through the solenoid vacuum switch then through the CTO switch and on to the vacuum advance unit. If the transmission shifts to any of the lower gears, the solenoid vacuum switch will block vacuum from reaching the advance unit on the distributor.

---

38. The lower portion of the CTO switch is in contact with the _____ _____.

---

39. An important substance in the CTO switch is a _____ _____ paste which controls the operation of the switch.

40. The paste in the CTO switch will be fully expanded as the engine coolant approaches approximately 160°F. The ball in the CTO switch will be in the _____ _____ of the switch body.

HOT CTO SWITCH

You will remember from the purpose section of this book that a hot coolant temperature override switch was built into some spark control systems to help cool the engine if it began to overheat. We will now see how this device functions and how it is connected into the spark control system.

Figure 6-25 shows a cut-away view of a hot coolant temperature override switch. As you can see, the hot coolant temperature override switch looks

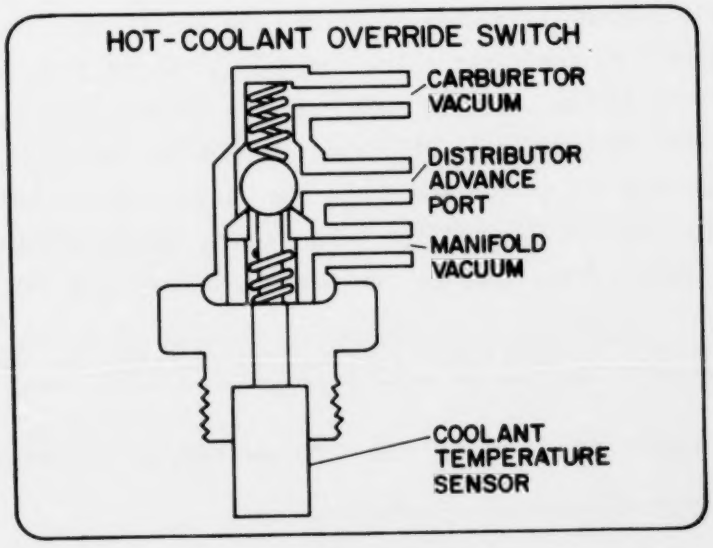

FIGURE 6-25

very similar to a cold coolant temperature override switch. It also functions the same way as a cold CTO switch.

The hot override CTO switch is built exactly like the CTO switch we just discussed. As with the cold override, the paste in the switch expands when it gets hot. The temperature at which the ball starts to move upward in the switch body, however, is much higher in a hot override switch. When the coolant temperature is below approximately 225°F, the ball valve will be in the lower portion of the switch body. When the ball valve is in this position, the upper two hose connections will be linked together. The switch in figure 6-25 is in this position.

As the coolant temperature approaches about 225°F, the ball will start to move upwards. When the coolant temperature is above 225°F the ball will be positioned in the upper portion of the valve body. When the ball is in this position the lower two hose connections will be linked together. The hot coolant temperature override switch will move to this position when the engine is overheating.

As you can see in figure 6-25, the upper hose connection of the hot CTO switch connects to the carburetor or ported vacuum source. The lower hose connection attaches to a manifold vacuum source. The center hose connection on the CTO switch is the distributor advance port.

With hose connections arranged in this manner, the desired vacuums will be routed to the distributor during the proper engine conditions. We will now look at the hot override switch in the spark control system.

Figure 6-26 shows how the hot override switch is connected into the spark control system. As you can see in figure 6-26, the engine coolant temperature is between 160°F and 225°F. Since this is the case, neither override switch will allow manifold vacuum to the advanct unit. As you can see in figure 6-26, ported vacuum is allowed to pass through both switches and on to the vacuum advance unit on the distributor. As you

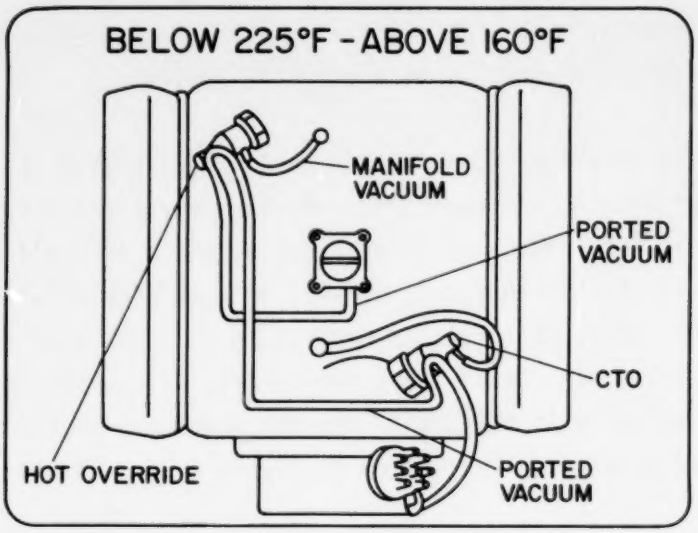

FIGURE 6-26

recall, when the coolant temperature reaches about 225°F, the ball in the hot override will move upwards in the switch body. This will direct manifold vacuum to the vacuum advance unit on the distributor. This condition is shown in figure 6-27. When the coolant temperature drops below 225°F, the hot CTO switch will again direct ported vacuum to the advance unit.

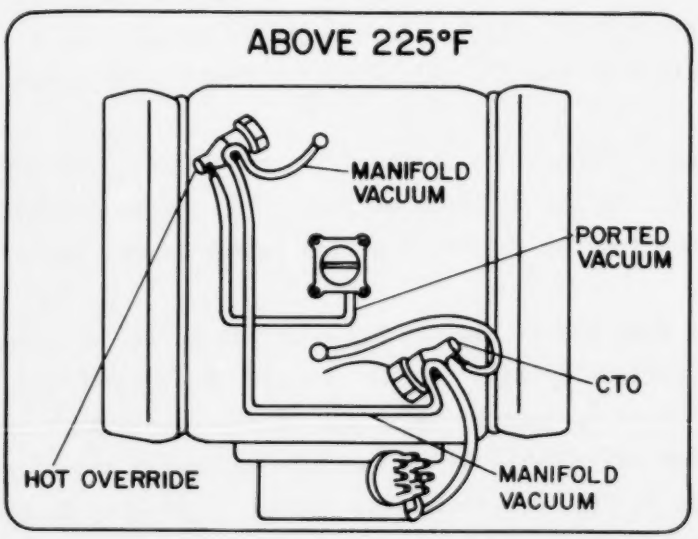

FIGURE 6-27

Now you should understand how the hot coolant temperature override switch works in this spark control system.

Figure 6-28 shows this spark control system with the vacuum solenoid valve. Remember that the vacuum solenoid valve will allow or block ported vacuum to the distributor. It will either allow or block ported vacuum depending on which gear the transmission has been shifted to.

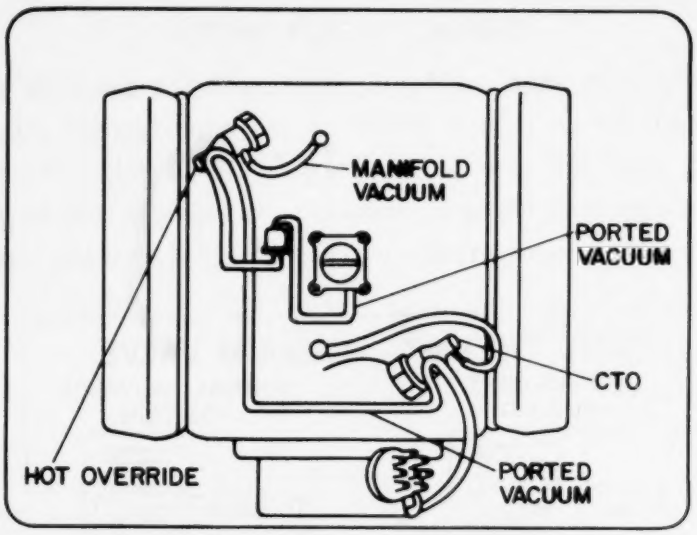

FIGURE 6-28

If the engine coolant is either above 225°F or below 160°F, a CTO switch will direct manifold vacuum to the advance unit. When the engine reaches normal operating temperature ported vacuum will again be used to advance the spark.

---

41. The upper hose connection of the CTO switch connects to _____ _____ vacuum.

---

42. When the coolant temperature reaches about 225°F, the ball in the _____ _____ will move upward in the switch body.

THERMAL VACUUM SWITCH

General Motors has used a slightly different hot override switch for their spark control system. This switch is called a Thermal Vacuum Switch. This switch does the same job as the hot CTO switch. The inside of this switch is slightly different, however. As you can see in figure 6-29, this switch has a small piston instead of a ball in the switch body. The

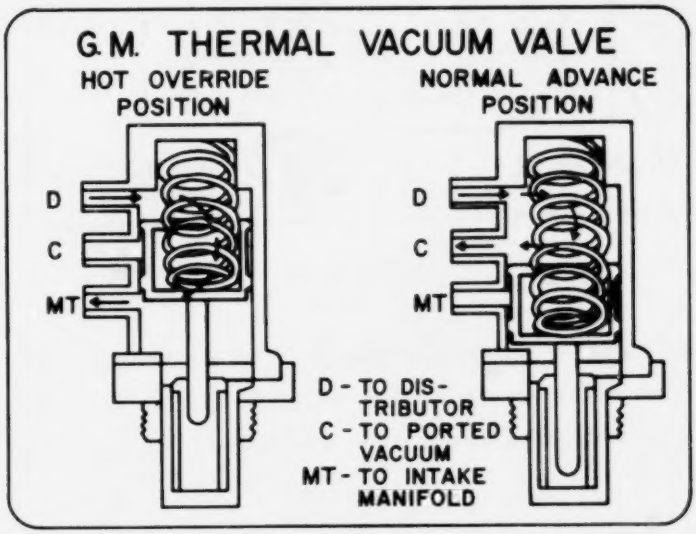

FIGURE 6-29

vacuum signal passes through the switch in a different fashion. For this reason, the vacuum line connections are arranged differently. This can also be seen in figure 6-29. Since these thermal vacuum switches look much the same as the hot CTO switch, but have different hose connections, it is very important to check the manufacturer's specifications for servicing any specific engine.

ELECTRONIC SPARK CONTROL SYSTEM

The next spark control system you will study is the ESC or Electronic Spark Control system. Figure 6-30 shows the components of the ESC system. The electronic amplifier is the heart of the ESC system. The electronic amplifier either energizes or de-energizes the vacuum solenoid valve. The amplifier does this by the messages it receives from the ambient temperature switch and the speed sensor.

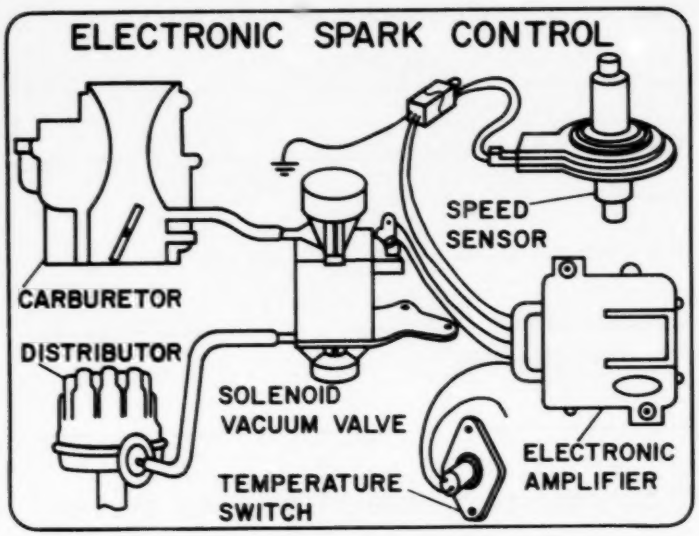

FIGURE 6-30

If the ambient air temperature is below approximately 65°F, the vacuum solenoid valve will be de-energized. This will allow the vacuum signal to reach the advance unit on the distributor. When the ambient air temperature is above 65°F, the electronic amplifier will energize the vacuum solenoid valve if the vehicle speed is below a pre-set value. When the vacuum solenoid valve is energized it will block vacuum from reaching the advance unit. When the speed sensor tells the electronic amplifier that the vehicle is traveling faster than the pre-set speed, the electronic amplifier will de-energize the vacuum solenoid valve. This will again allow vacuum to reach the advance unit on the distributor. With this system spark advance will only be allowed during cruise conditions and the HC and NO_x emissions will be reduced.

43. A slightly different hot override switch has been used by General Motors for thier spark control system. This switch is called a _____ _____ _____.

44. The inside of the TVS switch is slightly different from the CTO switch. This switch has a small _____ instead of a ball in the switch body.

45. ESC stands for _____ _____ _____.

46. The _____ _____ is the heart of the ESC system.

TRANSMISSION REGULATED SPARK SYSTEM

The TRS or Transmission Regulated Spark system functions very much like

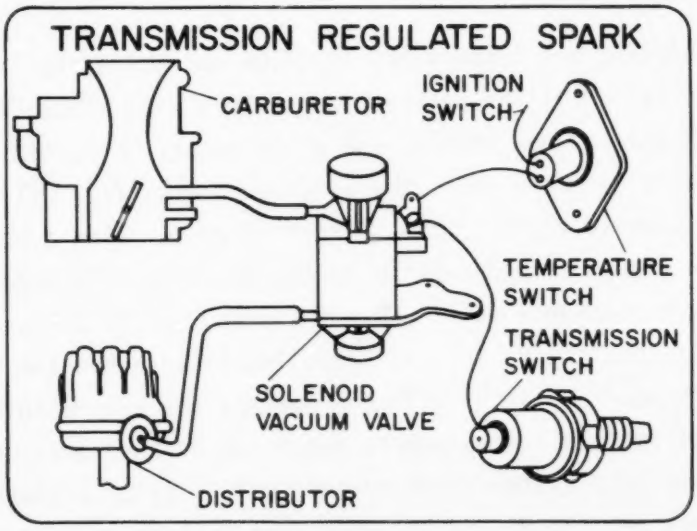

FIGURE 6-31

the ESC system we just discussed. This system, however, uses a transmission switch instead of the speed sensor and electronic amplifier. Both the transmission switch and the air temperature switch must be closed to energize the solenoid vacuum valve.

When the solenoid vacuum valve is energized, no vacuum will be allowed to the advance unit. When the transmission is in any of the lower gears, it will complete the electrical circuit and energize the vacuum solenoid. When the transmission shifts into high gear, the transmission switch will open. This will de-energize the solenoid and allow vacuum advance. The air temeprature switch will open any time the air is below 50°F. This will allow vacuum advance until the air temperature increases above 50°F. Once the air temperature is above 50°F, the transmission switch controls when advance will be allowed and denied.

SPARK DELAY SYSTEM

The last two spark control systems we will look at are very simple. The first of these is the spark delay system. As you recall, this system only has one component. This is the spark delay valve.

The spark delay valve is located in the vacuum line between the carburetor ported vacuum tap and the advance unit on the distributor. You must remember that this vacuum will drop to 0" Hg every time the throttle plates close or are fully open. When this vacuum does go to 0", the vacuum advance will be denied immediately. When the ported vacuum signal increases again, it will be delayed for a few seconds before it is allowed to advance the spark. Let's now take a look inside the spark delay valve and see how it delays this vacuum signal.

Figure 6-32 shows the inside of a spark delay valve. This figure shows the delay valve with a vacuum condition on the carburetor side of the valve. When the spark delay valve is in this position the air in the advance unit and vacuum line will be slowly drawn through the valve.

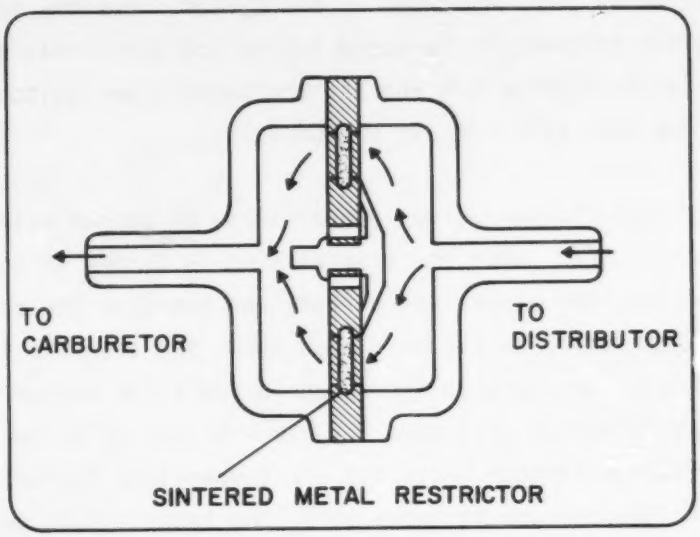

FIGURE 6-32

You can see in figure 6-32 a sintered metal restrictor is used in the delay valve. The air in the distributor advance unit will slowly pass through the metal restrictor. This is how the vacuum is delayed. It takes a few seconds for the air to bleed through the restriction.

When the ported vacuum signal drops to 0", air will rush into the

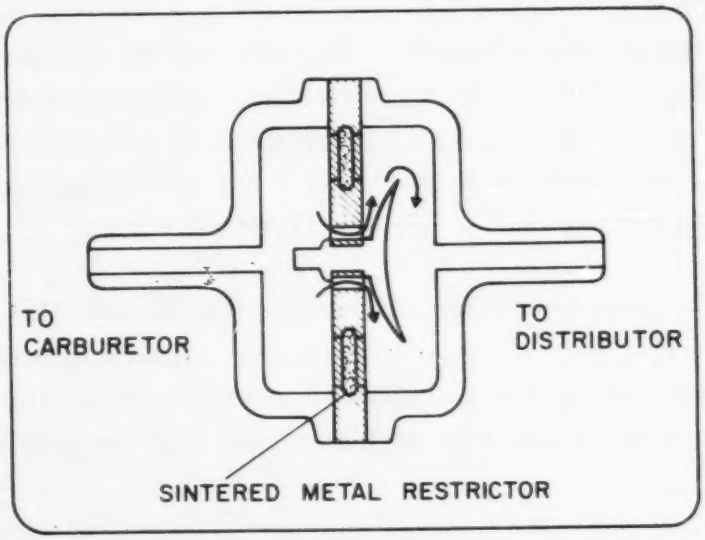

FIGURE 6-33

carburetor side of the delay valve. This air will unseat the small rubber check valve inside the delay valve body. This will immediately remove the vacuum condition in the advance unit. Figure 6-33 shows the delay valve in this condition.

ORIFICE SPARK ADVANCE CONTROL SYSTEM

Now that you understand how the delay valve spark control system functions, we will look briefly at the last spark control system. This is the Orifice Spark Advance Control system.

Figure 6-34 shows the OSAC valve and how it is connected to the carburetor and distributor. This valve functions the very same way as the

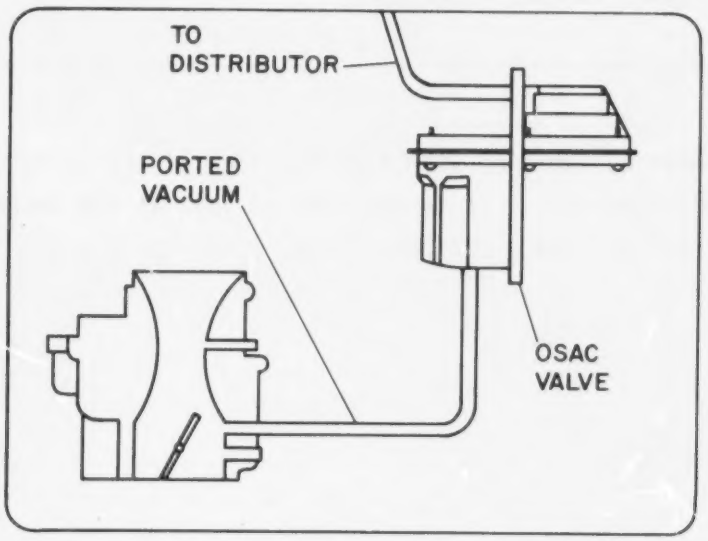

FIGURE 6-34

spark delay valve. It will delay the vacuum signal from reaching the distributor. It will vent the vacuum from the distributor at the same time the ported vacuum signal goes to 0" Hg. The OSAC valve may, however, have a temperature override. If the OSAC valve is so equipped, it will not delay the vacuum signal if the temperature is below 60°F. It will not start delaying the vacuum until the air temperature is above 60°F.

47. TRS stands for _____ _____ _____ system.

48. The TRS system uses a _____ switch instead of the speed sensor and electronic amplifier.

49. The _____ _____ valve is the only component in the spark delay system.

Now you should be familiar with the function of the various spark control systems and components. It is now time to look at the inspection procedures for the spark control system.

SYSTEM INSPECTION

An inspection of the Spark Control system should be made periodically and prior to any testing of the system. This inspection will require no tools and takes only a few minutes. Many problems may be avoided or corrected by these steps.

1. Obtain a good service manual and see that all components are properly installed on the engine. Make sure no modifications have been done to the system or any of its components. All vacuum and electrical components should be in place.

   In order for the spark control system to operate properly, all components must be installed on the vehicle.

2. Check the system connecting hoses for cracks, deterioration and loose connections.

   Any air leaks in the hoses will reduce the spark control system's effectiveness. If any vacuum line is leaking severely, a lean miss condition may occur.

3. Check the electrical wires in the system for cracks, frays or other deterioration in the insulation. Also check the wire connectors for improper fits, dirt and corrosion.

   If any shorted, grounded, or open wires are present in the spark control system, the vehicle will not operate correctly. Performance, driveability and emissions can all suffer if poor wiring exists in the system.

A good visual inspection should take only a few minutes. This inspection can show you where trouble might occur and can solve some problems before you begin testing the spark control system.

50. When inspecting the spark control system check the system connecting _____ for cracks, deterioration and loose connections.

51. Performance, driveability and _____ can all suffer if poor wiring exists in the spark control system.

SYSTEM TESTING

Now that you are familiar with the spark control system, we will look at some of the test procedures for this system. Since there are many variations in spark control systems, you must always check the manufacturer's recommended test procedures for the specific automobile you are working with.

When testing the transmission control spark system with an automatic transmission, it is first necessary to identify if the transmission switch is installed in the governor oil pressure circuit or connected to the direct clutch circuit. A good service manual should tell you which method is used on the car you are working with.

TESTING THE TCS SYSTEM

If the transmission switch is connected to the governor oil pressure circuit, it will be necessary to do the following:

1. Raise the rear wheels and install safety stands.
2. Install a vacuum gauge in the vacuum hose just before the vacuum advance unit on the distributor.
3. Start the engine.
4. Put the transmission in drive.

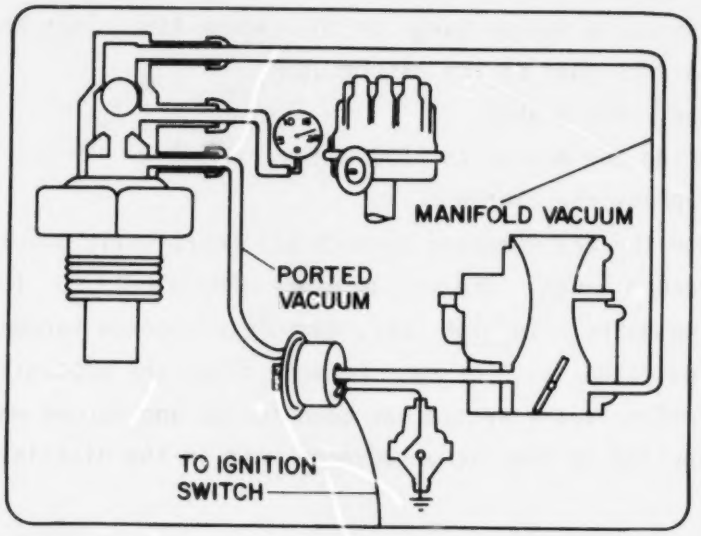

FIGURE 6-35

5. Once the engine coolant has warmed to operating temperature, maintain speeds of 0-40 MPH.
6. The vacuum gauge should allow ported vacuum as you reach speeds of approximately 40 MPH.
7. Use a timing light to verify that the vacuum advance unit is working.

If the transmission switch is installed in the direct clutch circuit on the automatic transmission, the following is needed to check the system:

1. Install a vacuum gauge in the vacuum hose, just before the vacuum advance unit on the distributor.
2. Start the engine.
3. Apply the brakes.
4. Put the transmission in reverse.
5. Once the coolant has reached normal operating temperature, increase the engine speed to 1500 RPM.
6. At this time, vacuum should be applied to the distributor advance unit on the distributor.

If the automobile is equipped with a standard transmission, it can be checked by the following:

1. Bring the engine to normal operating temperature.
2. Connect a vacuum gauge to the vacuum line, just before the advance unit on the distributor.
3. Apply the brakes.
4. Bring the engine to 1500 RPM.
5. Depress the clutch.
6. Run the transmission through all gears while observing the vacuum gauge. The vacuum gauge should read "0" in all low gears. In high gear, carburetor ported vacuum should be indicated. If for some reason, after the transmission control spark system has been tested and vacuum was not applied to the vacuum advance unit on the distributor,

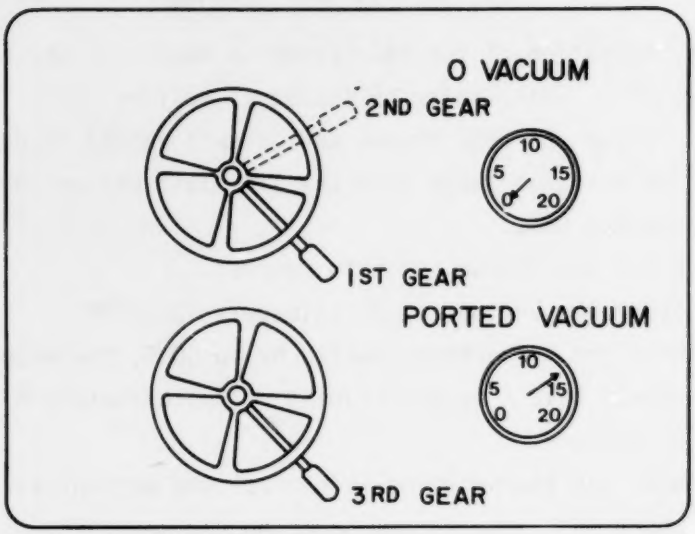

FIGURE 6-36

it becomes necessary to follow manufacturer's technical or shop manual for exact procedures for testing individual components.

---

52. When testing the transmission control spark system with an automatic transmission, it is first necessary to identify if the transmission switch is installed in the governor oil pressure circuit or connected to the _____ _____ _____.

---

53. If the transmission switch is connected to the governor oil pressure circuit, it will be necessary to use a _____ _____ to verify that the vacuum advance unit is working.

TESTING THE ESC SYSTEM

Testing the operation of the ESC system is much like any of the spark control systems. This system is tested as follows:

1. Jack up the rear wheels and install safety stands.
2. Tee a vacuum gauge into the line just before the distributor advance unit.
3. Place the transmission in neutral.
4. Speed the engine to approximately 1500 RPM.
5. With the temperature switch below 50°F, the vacuum gauge should have a vacuum reading of approximately 6 to 10 inches of mercury.
6. With the transmission in neutral and ambient air temperature above 65°F, the vacuum gauge should read "0".
7. Shift the transmission into gear and accelerate slowly to between approximately 28 to 35 MPH. The vacuum gauge should read at least 6 inches of vacuum.

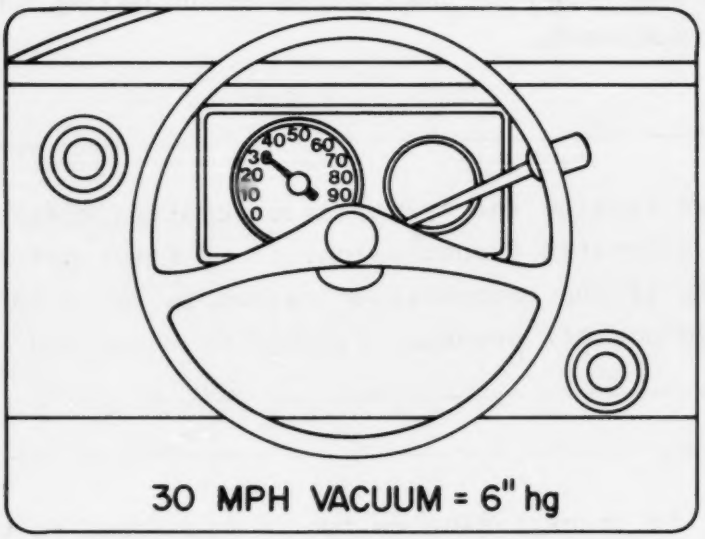

FIGURE 6-37

8. Start allowing the engine to decelerate. Somewhere between 18 and 15 MPH the vacuum gauge reading should drop to 0.

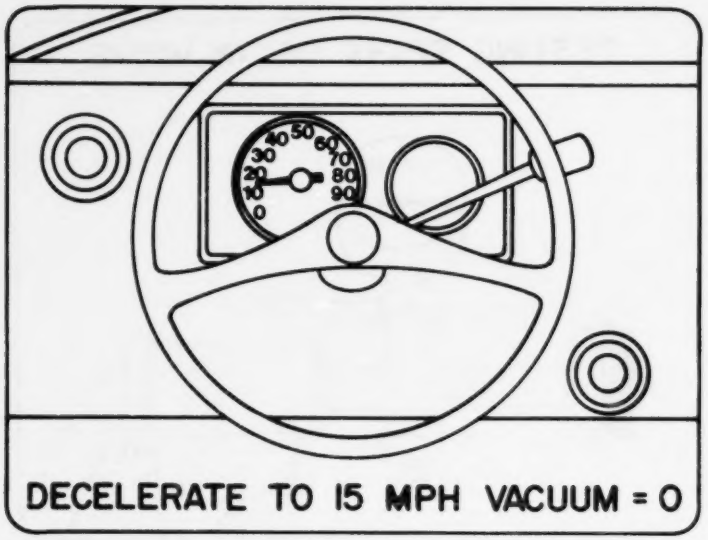

FIGURE 6-38

This is an operational procedure test and it is important to check the manufacturer's technical or shop manual for exact procedures for each make and model of automobile.

SPARK DELAY VALVE TEST

When testing a spark delay valve with a hand vacuum pump, connect the pump to the black side of the valve. You should be able to pump up

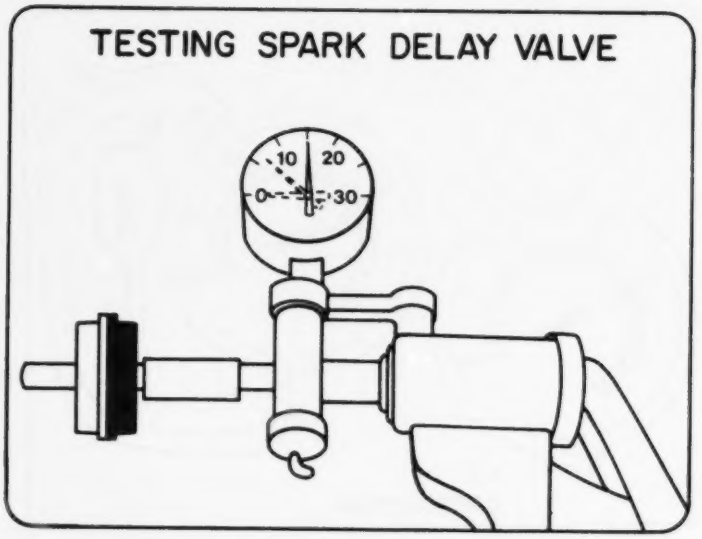

FIGURE 6-39

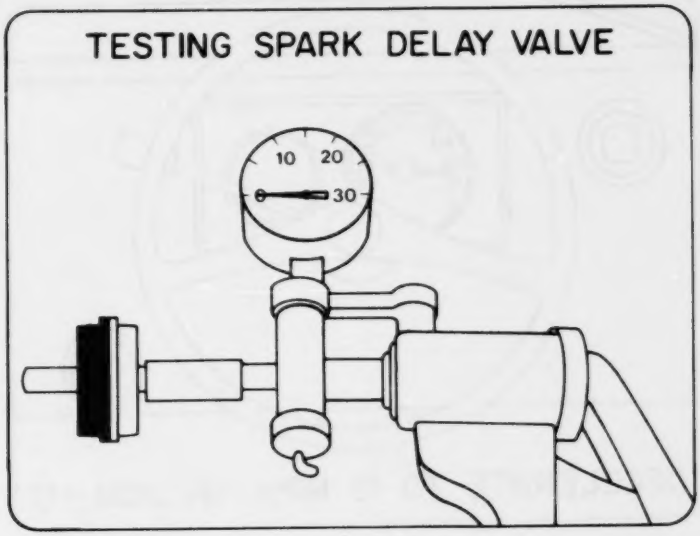

FIGURE 6-40

vacuum and the gauge will slowly drop to 0. If the gauge does not drop to 0, the valve is plugged. When the hand pump is connected to the colored side of the spark delay valve, no vacuum can be pumped. If vacuum can be pumped, the valve is not working correctly.

OSAC VALVE TEST

In testing the OSAC valve, all that is necessary to do is to bring the

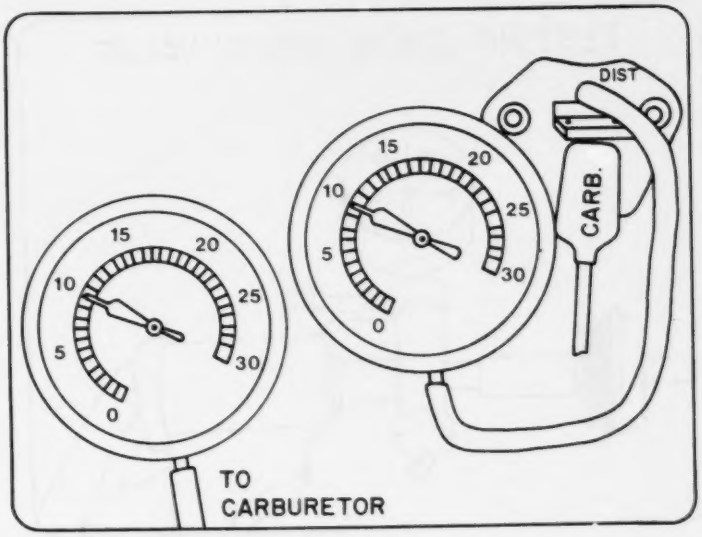

FIGURE 6-41

engine to curb idle and have an outside temperature of approximately 60°F or more. Check to make sure that vacuum is being applied to the OSAC valve and install a vacuum gauge in the hose from the OSAC valve to the distributor. Increase the engine speed to approximately 2000 RPM and hold it there. The vacuum gauge should rise slowly to the maximum vacuum in a few seconds. If no vacuum shows on the vacuum gauge after approximately 17 seconds, this shows that the OSAC valve is defective. Also, it should be noted, that the vacuum should increase slowly proving that the valve is working correctly.

---

54. When testing a spark delay valve with a hand vacuum pump, connect the pump to the black side of the valve. You will be able to pump up vacuum and the gauge will _____ _____ to 0.

---

55. In testing the OSAC valve, when the engine is accelerated to 2000 RPM, vacuum to the distributor should be delayed for about ____ seconds.

SYSTEM SUMMARY

PURPOSE

The purpose of the spark control system is to control the advance and retard of the ignition spark to improve combustion and reduce the formation of hydrocarbons (HC) and oxides of nitrogen (NO_x) during varying engine operations.

MAIN COMPONENTS

Coolant Temperature Switch - Senses cooling system temperature and allows vacuum advance only when the engine is cold.

Hot Override Switch - Senses cooling system temperature and allows full vacuum when the engine starts to overheat.

Transmission Switch - Prevents vacuum advance in all gears except high gear.

Vacuum Advance Solenoid Valve - A two-position valve allowing vacuum to reach the distributor advance unit or venting air preventing vacuum advance

SYSTEM FUNCTION

The spark control system operates to allow vacuum advance when the coolant temperature is cold, or when the transmission is in high gear. At other times, the spark is in retard position which increases exhaust gas temperature, promoting additional burning of hydrocarbons (HC) in the exhaust manifold. Retarded spark will also lower peak combustion temperature (by igniting spark later in the cycle) thereby reducing oxides of nitrogen (NO_x) formation.

Some manufacturers use the following individual components on certain engines to control spark advance.

Orifice Spark Advance Control (OSAC) - This system is now used on all Chrysler products. Its function is to delay vacuum advance for approximately 30-45 seconds under normal engine temperatures. When the engine

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air cleaner temperature is below 50°F, vacuum will flow through the valve unrestricted. The valve is mounted in the air cleaner assembly.

Spark Delays - Ford has used a number of spark delay valves operating similar to Chrysler's OSAC valve. This delay serves to lower HC emissions by not allowing full vacuum advance until the vehicle has been cruising for 7-20 seconds. The spark delays used by Ford do not contain a cold engine by-pass system. The spark delay valves are normally found mounted in the vacuum line near the distributor.

Electronic Spark Control (ESC) - Operates similar to the transmission switch discussed in the main components of the spark comtrol system. However, the ESC uses an electrical signal from a temperature switch mounted in the left front door pillar in some 71-73 Fords to activate an amplifier which in turn supplies the signal to the vacuum advance.

ANSWERS

1. oxides of nitrogen
2. combustion process
3. hydrocarbon emissions
4. exhaust manifold
5. heavy load
6. ignition timing
7. piston
8. exhaust gas
9. advanced ignition
10. vacuum solenoid
11. electrical circuit
12. transmission
13. first and second
14. vacuum solenoid
15. cold temperature override
16. manifold vacuum
17. hot override
18. Electronic Spark
19. accelerating
20. voltage signal
21. electronic amplifier's
22. Transmission Regulated Spark
23. transmission
24. spark delay
25. delay valve
26. orifice spark advance control
27. distributor advance or vacuum advance
28. wire coil
29. electrical terminals or hose connections
30. magnetic field
31. current
32. ignition switch
33. series
34. transmission
35. hydraulic pressure
36. linkage
37. de-energized
38. engine coolant
39. heat sensitive
40. upper portion or upper p
41. intake manifold
42. hot override
43. thermal vacuum switch
44. piston
45. Electronic Spark Control
46. electronic amplifier
47. Transmission Regulated Sp
48. transmission
49. spark delay
50. hoses
51. emissions
52. direct clutch circuit
53. timing light
54. slowly drop
55. 17

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